PCBCafe

#40 Schmidt Trigger Oscillator

Like the Wein bridge oscillator, the Schmidt trigger only needs a power supply of 5 to 15 volts to begin its oscillation. This entails that the maximum lead that the clock pulse can drive is in the 1 milliamp range. The oscillation is controlled by the RC time constant and the hysterics native to the Schmidt trigger. The output of the Schmidt trigger charges the timing capacitor through the resistor creating the ramp signal. The ramp signal bounces back and forth between the positive and negative hysterisis point of the Schmidt trigger.

To write a model for a Schmidt trigger, the most key parameter is the positive and negative hysterisis points. Unfortunately, manufactures of the Schmidt trigger give a loose specification as to what these points are. Figure 40-1 shows data taken from the Harris Semiconductor Databook on the CD4093BMS NAND Schmidt Trigger.

Figure 40-1: CD4093BMS NAND Schmidt Trigger Specifications

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	MAX	UNITS
Positive Trigger Threshold Voltage	VP5V	VDD=5V (Note 4)	-55 - +125	2.6	4	V
Negative Trigger Threshold Voltage	VN5V	VDD=5V (Note 4)	-55 - +125	1.4	3.2	V
Hysteresis Voltage	VH5V	VDD=5V (Note 4)	-55 - +125	0.3	1.6	V

As you can see, it is unclear at what voltage level the hysterisis will center around or what the separation between the positive and negative switching points will be. A good model should hit the average of the specification, but it is unlikely that a part will perform in a similar manner. Realistically, the person who wrote the spice model, wrote it for a single part. Any model that performs within the specification limits of the device could be considered as correct. This makes for some interesting results from the models included with the different packages.

Consider the CD4093B model contained in the IsSpice package. The circuit is shown as figure 40-2.

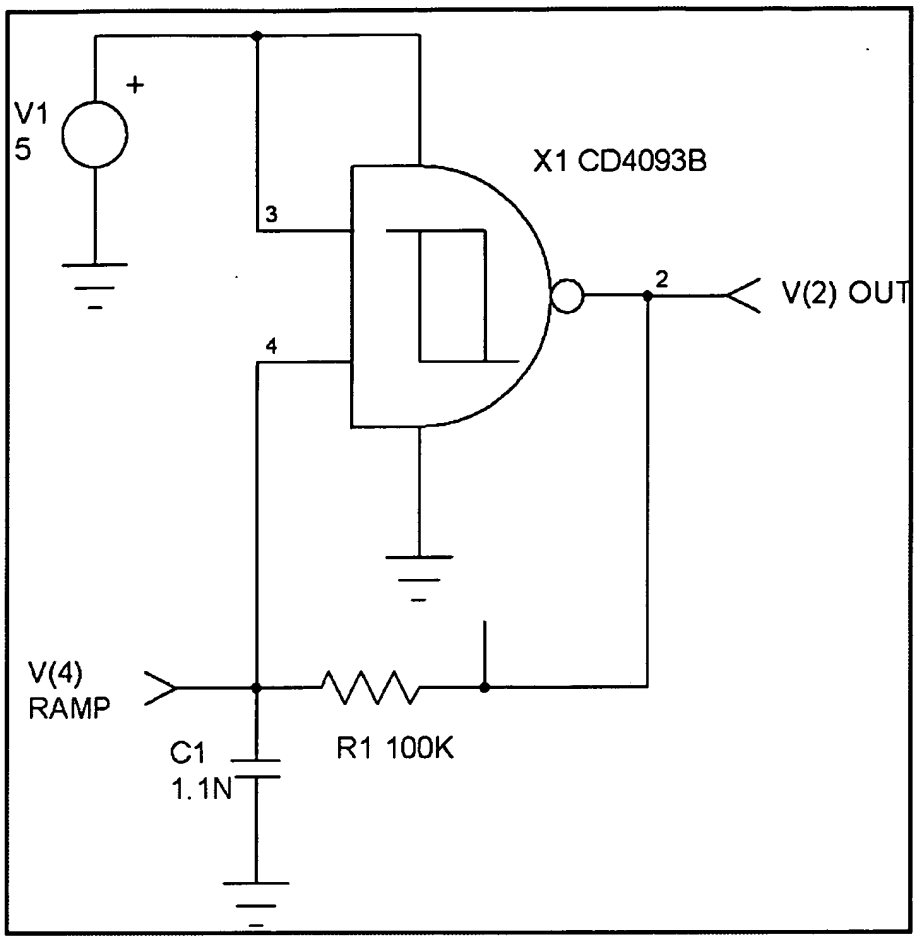

Figure 40-2: Schmidt Trigger Oscillator

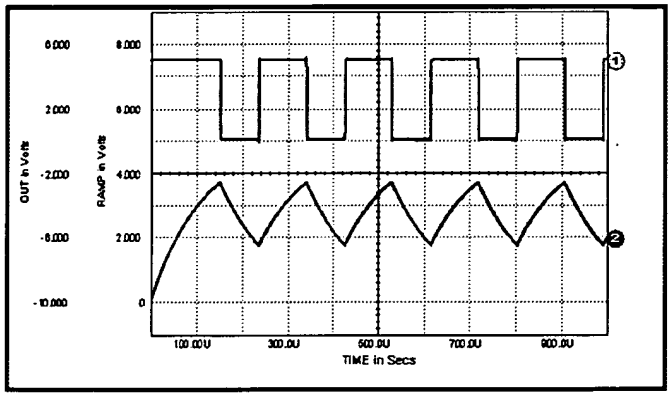

Figure 40-3: Results of IsSpice Schmidt Trigger

The IsSpice model shows that the ramp voltage peaks at 3.7 volts and has a minimum of 1.75 volts. The maximum is below the extreme high specification of 4 volts, and the minimum is above the extreme minimum specification of 1.4 volts. This seems to line up pretty close to the data sheet, but the models hysterisis voltage is 1.95 volts and the specified maximum is only 1.6 volts. The IsSpice version of the Schmidt trigger would work for some applications where the hysterisis voltage is not so critical, but for this application, the large hysterisis value caused a much lower frequency then expected. The IsSpice models frequency is 5.29 kHz.

The Pspice program did not contain model for the CD4093, so a 7414 was used in its place. The 7414 is the digital model for the Schmidt trigger inverter. To use the digital device for an analog measurement, E sources (voltage controlled voltage sources) were used as buffers. The schematic used for the Pspice model is shown as figure 40-4. The results are displayed as figure 40-5.

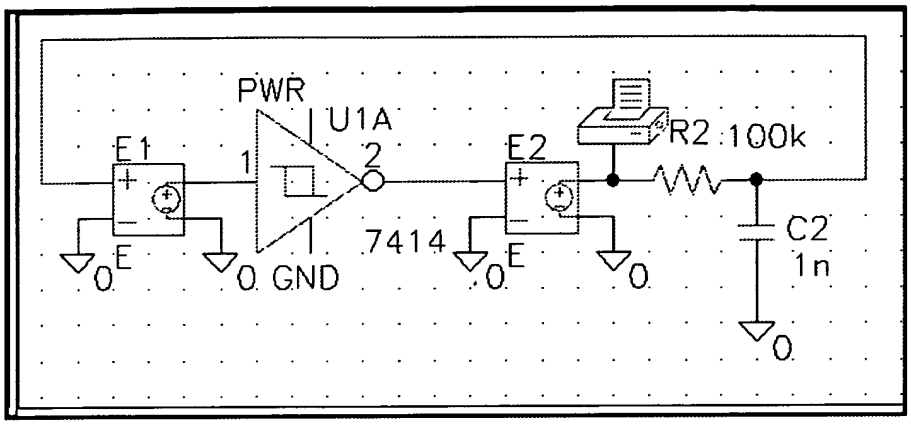

Figure 40-4: Pspice using digital Schmidt trigger

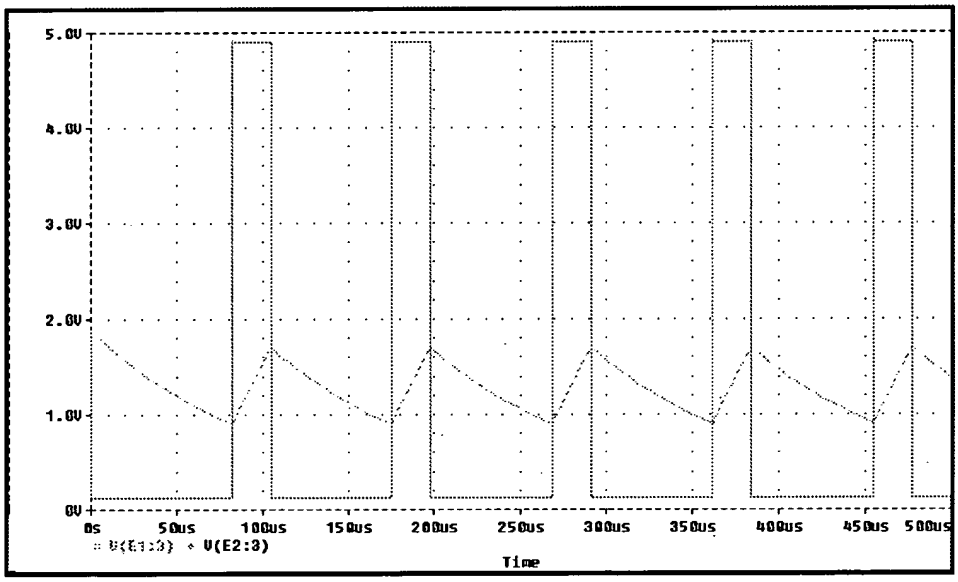

Figure 40-5: Pspice results of Schmidt trigger oscillator

The results of the Pspice digital model show that the hysterisis voltage is within the specification limits at 790 mV. The minimum positive threshold voltage is 1.65 V and model shows it at 1.69, meeting this specification also. The only problem is the model does not meet the minimum negative threshold of 1.1 V, the model shows it down at 0.9 V. With the exception of the negative threshold, Pspice has a valid model of the schmidt trigger. Unfortunately the negative threshold of the Pspice model causes an this particular circuit to not report the a proper duty cycle or frequency.

Microcap has a model of the CD4093A. The results of the simulation of the Microcap model are shown as figure 40-6.

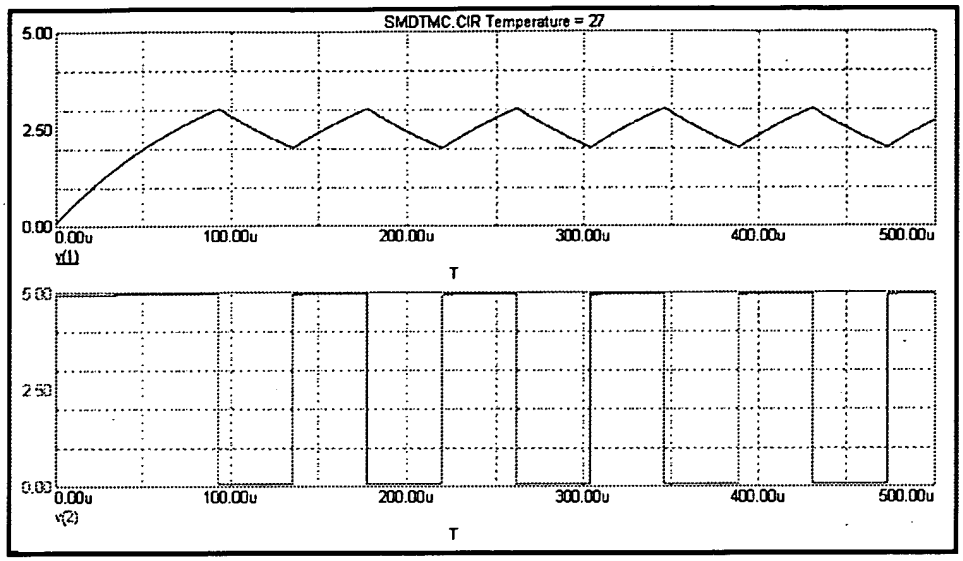

Figure 40-6: Microcap results of Schmidt trigger oscillator

The microcap results correlate very well to the data sheet. The hysterisis voltage is right at one volt, well within the limits of the 0.3 to 1.6 volt limits. The positive threshold voltage is 3 volts which is within the 2.6 to 4 volt limit. The negative threshold voltage is 2 volts which is between the 1.4 to 3.2 volt limit. Microcap's model of the schmidt trigger is clearly valid from the for the parameters evaluated in this comparison.

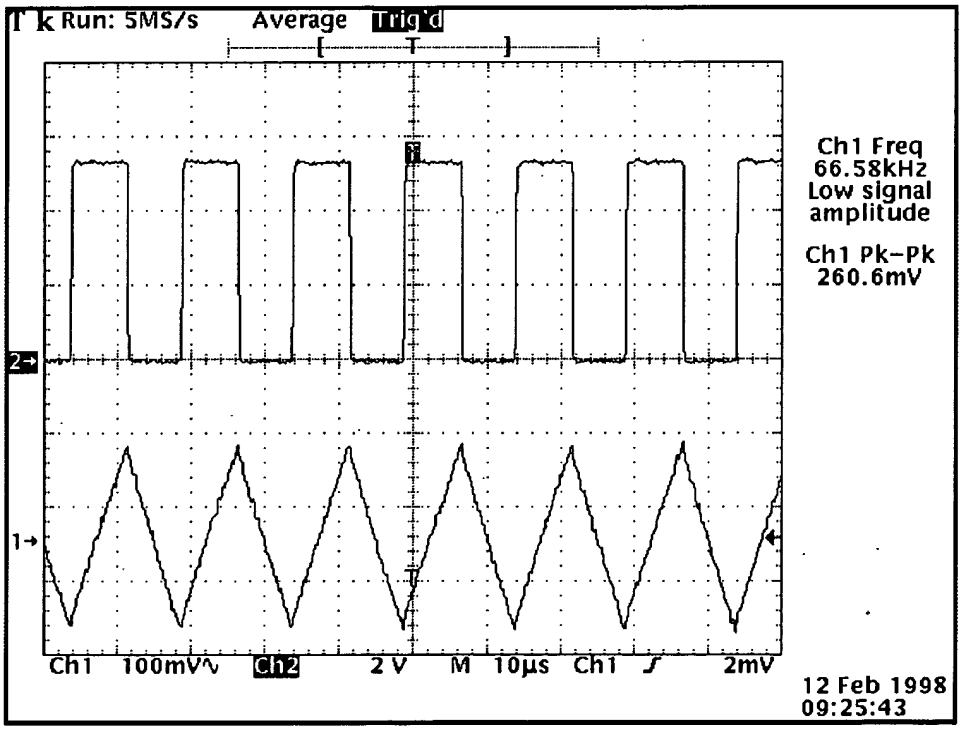

Figure 40-7: Circuit board data from Schmidt trigger oscillator

Comparing the Spice models to the measured data shown in figure 40-7 is difficult to do. The measured data shows the hysterisis voltage to be 250 mV. This does not meet the minimum specification limit of 300 mV. The minimum

and maximum threshold voltages were close to 2.5 volts which does meet the specification limit. These measurements bring out a serious problem with this type of circuit. The frequency of oscillation can change dramatically due to the wide variance of hysterisis voltage, causing difficulty in modeling this circuit.

Run Time Summary		
IsSpice v 7.6	PsPice v 6.3	Micro-Cap V v2
154.233 Sec	204.11 Sec	255.488 Sec
Advantages: Low part count, good drive capability.		
Disadvantages: Frequency of oscillation and duty cycle unpredictable due to poor tolerance of hysterisis voltage and voltage thresholds.		

References

Kielkowski, Ron M. 1994. Inside Spice. New York: McGraw Hill.

National Semiconductor, 1994. Linear Applications Handbook.

Parker, Sybil, ed. 1984. Concise Encyclopedia of Science and Technology. New York: McGraw Hill

Harris Semiconductor, 1993. Radiation Hardened Product Databook.